17. What type of mirror is shown in Fig. 23–50? Explain.

FIGURE 23–50
Question 17 and Problem 15.

18. Light rays from stars (including our Sun) always bend toward the vertical direction as they pass through the Earth's atmosphere. (*a*) Why does this make sense? (*b*) What can you conclude about the apparent positions of stars as viewed from Earth? Draw a circle for Earth, a dot for you, and 3 or 4 stars at different angles.

19. Where must the film be placed if a camera lens is to make a sharp image of an object far away? Explain.

20. A photographer moves closer to his subject and then refocuses. Does the camera lens move farther away from or closer to the camera film or sensor? Explain.

21. Can a diverging lens form a real image under any circumstances? Explain.

22. Light rays are said to be "reversible." Is this consistent with the thin lens equation? Explain.

23. Can real images be projected on a screen? Can virtual images? Can either be photographed? Discuss carefully.

24. A thin converging lens is moved closer to a nearby object. Does the real image formed change (*a*) in position, (*b*) in size? If yes, describe how.

25. If a glass converging lens is placed in water, its focal length in water will be (*a*) longer, (*b*) shorter, or (*c*) the same as in air. Explain.

26. Compare the mirror equation with the thin lens equation. Discuss similarities and differences, especially the sign conventions for the quantities involved.

27. A lens is made of a material with an index of refraction $n = 1.25$. In air, it is a converging lens. Will it still be a converging lens if placed in water? Explain, using a ray diagram.

28. (*a*) Does the focal length of a lens depend on the fluid in which it is immersed? (*b*) What about the focal length of a spherical mirror? Explain.

29. An underwater lens consists of a carefully shaped thin-walled plastic container filled with air. What shape should it have in order to be (*a*) converging, (*b*) diverging? Use ray diagrams to support your answer.

30. The thicker a double convex lens is in the center as compared to its edges, the shorter its focal length for a given lens diameter. Explain.

***31.** A non-symmetrical lens (say, planoconvex) forms an image of a nearby object. Use the lensmaker's equation to explain if the image point changes when the lens is turned around.

***32.** Example 23–16 shows how to use a converging lens to measure the focal length of a diverging lens. (*a*) Why can't you measure the focal length of a diverging lens directly? (*b*) It is said that for this to work, the converging lens must be stronger than the diverging lens. What is meant by "stronger," and why is this statement true?

MisConceptual Questions

1. Suppose you are standing about 3 m in front of a mirror. You can see yourself just from the top of your head to your waist, where the bottom of the mirror cuts off the rest of your image. If you walk one step closer to the mirror
(*a*) you will not be able to see any more of your image.
(*b*) you will be able to see more of your image, below your waist.
(*c*) you will see less of your image, with the cutoff rising to be above your waist.

2. When the reflection of an object is seen in a flat mirror, the image is
(*a*) real and upright.
(*b*) real and inverted.
(*c*) virtual and upright.
(*d*) virtual and inverted.

3. You want to create a spotlight that will shine a bright beam of light with all of the light rays parallel to each other. You have a large concave spherical mirror and a small lightbulb. Where should you place the lightbulb?
(*a*) At the focal point of the mirror.
(*b*) At the radius of curvature of the mirror.
(*c*) At any point, because all rays bouncing off the mirror will be parallel.
(*d*) None of the above; you can't make parallel rays with a concave mirror.

4. When you look at a fish in a still stream from the bank, the fish appears shallower than it really is due to refraction. From directly above, it appears
(*a*) deeper than it really is.
(*b*) at its actual depth.
(*c*) shallower than its real depth.
(*d*) It depends on your height above the water.

5. Parallel light rays cross interfaces from medium 1 into medium 2 and then into medium 3 as shown in Fig. 23–51. What can we say about the relative sizes of the indices of refraction of these media?
(*a*) $n_1 > n_2 > n_3$.
(*b*) $n_3 > n_2 > n_1$.
(*c*) $n_2 > n_3 > n_1$.
(*d*) $n_1 > n_3 > n_2$.
(*e*) $n_2 > n_1 > n_3$.
(*f*) None of the above.

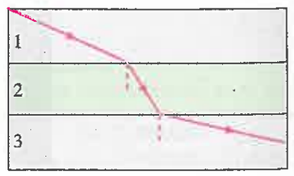

FIGURE 23–51
MisConceptual Question 5.

6. To shoot a swimming fish with an intense light beam from a *laser gun*, you should aim
(*a*) directly at the image.
(*b*) slightly above the image.
(*c*) slightly below the image.

7. When moonlight strikes the surface of a calm lake, what happens to this light?
(*a*) All of it reflects from the water surface back to the air.
(*b*) Some of it reflects back to the air; some enters the water.
(*c*) All of it enters the water.
(*d*) All of it disappears via absorption by water molecules.

8. If you shine a light through an optical fiber, why does it come out the end but not out the sides?
(*a*) It does come out the sides, but this effect is not obvious because the sides are so much longer than the ends.
(*b*) The sides are mirrored, so the light reflects.
(*c*) Total internal reflection makes the light reflect from the sides.
(*d*) The light flows along the length of the fiber, never touching the sides.

9. A converging lens, such as a typical magnifying glass,
(*a*) always produces a magnified image (taller than object).
(*b*) always produces an image smaller than the object.
(*c*) always produces an upright image.
(*d*) always produces an inverted image (upside down).
(*e*) None of these statements are true.

10. Virtual images can be formed by
(*a*) only mirrors.
(*b*) only lenses.
(*c*) only plane mirrors.
(*d*) only curved mirrors or lenses.
(*e*) plane and curved mirrors, and lenses.

11. A lens can be characterized by its *power*, which
(*a*) is the same as the magnification.
(*b*) tells how much light the lens can focus.
(*c*) depends on where the object is located.
(*d*) is the reciprocal of the focal length.

12. You cover half of a lens that is forming an image on a screen. Compare what happens when you cover the top half of the lens versus the bottom half.
(*a*) When you cover the top half of the lens, the top half of the image disappears; when you cover the bottom half of the lens, the bottom half of the image disappears.
(*b*) When you cover the top half of the lens, the bottom half of the image disappears; when you cover the bottom half of the lens, the top half of the image disappears.
(*c*) The image becomes half as bright in both cases.
(*d*) Nothing happens in either case.
(*e*) The image disappears in both cases.

13. Which of the following can form an image?
(*a*) A plane mirror.
(*b*) A curved mirror.
(*c*) A lens curved on both sides.
(*d*) A lens curved on only one side.
(*e*) All of the above.

14. As an object moves from just outside the focal point of a converging lens to just inside it, the image goes from _____ and _____ to _____ and _____.
(*a*) large; inverted; large; upright.
(*b*) large; upright; large; inverted.
(*c*) small; inverted; small; upright.
(*d*) small; upright; small; inverted.

For assigned homework and other learning materials, go to the MasteringPhysics website.

Problems

23–2 Reflection; Plane Mirrors

1. (I) When you look at yourself in a 60-cm-tall plane mirror, you see the same amount of your body whether you are close to the mirror or far away. (Try it and see.) Use ray diagrams to show why this should be true.

2. (I) Suppose that you want to take a photograph of yourself as you look at your image in a mirror 3.1 m away. For what distance should the camera lens be focused?

3. (II) Two plane mirrors meet at a 135° angle, Fig. 23–52. If light rays strike one mirror at 34° as shown, at what angle ϕ do they leave the second mirror?

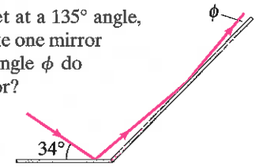

FIGURE 23–52
Problem 3.

4. (II) A person whose eyes are 1.72 m above the floor stands 2.20 m in front of a vertical plane mirror whose bottom edge is 38 cm above the floor, Fig. 23–53. What is the horizontal distance x to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?

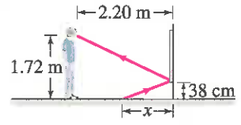

FIGURE 23–53
Problem 4.

5. (II) Stand up two plane mirrors so they form a 90.0° angle as in Fig. 23–54. When you look into this double mirror, you see yourself as others see you, instead of reversed as in a single mirror. Make a ray diagram to show how this occurs.

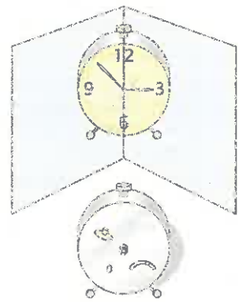

FIGURE 23–54
Problem 5.

6. (II) Two plane mirrors, nearly parallel, are facing each other 2.3 m apart as in Fig. 23–55. You stand 1.6 m away from one of these mirrors and look into it. You will see multiple images of yourself. (*a*) How far away from you are the first three images of yourself in the mirror in front of you? (*b*) Are these first three images facing toward you or away from you?

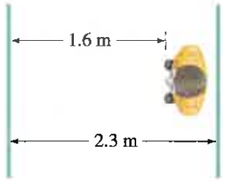

FIGURE 23–55
Problem 6.